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A REPORT ON INSTRUCTIONAL DEVICES IN FOREIGN LANGUAGE TEACHING.

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RECOMMENDATIONS FALL INTO 3 CATEGORIES. FIRST, THE ROLE OF TEACHING DEVICES SHOULD BE MAJOR BECAUSE THEIR SUCCESS COULD RESULT IN ECONOMIC AND MANPOWER ADVANTAGES WHICH USUALLY HAVE TO AWAIT A NEW GENERATION OF TEACHERS TRAINED IN A GIVEN DISCIPLINE. LESS THAN FULL USE OF DEVICES COULD LEAD TO DEPENDENCE ON TRADITIONAL INSTRUCTIONAL TECHNIQUES OFTEN BASED MORE ON WHIM THAN ON PSYCHOLOGICAL KNOWLEDGE. SECOND, TEACHING DEVICES PROVIDE EXCELLENT RESEARCH OPPORTUNITIES TO EXPLORE INNOVATIONS IN TEACHING AND ALLOW COLLABORATION OF EDUCATORS AND PSYCHOLOGISTS. THIRD, THE SELECTION OF APPROPRIATE DEVICES DEPENDS MOST HIGHLY ON THE PROVISION OF APPROPRIATE PSYCHOLOGICAL FUNCTIONS--ABILITY TO PRESENT AUDITORY AND VISUAL STIMULI TO THE STUDENT, PROVISION FOR A MEANS OF RESPONDING, AND CONFIRMATION OF THE STUDENT'S RESPONSES. ALSO IMPORTANT ARE FLEXIBILITY IN PRESENTATION OF LESSON MATERIALS, EASILY AND INEXPENSIVELY PREPARED MATERIALS, SIMPLICITY, RELIABILITY, ECONOMY, AND TIME. THREE SPECIFIC DEVICES ARE COMPARED--A COMBINATION SLIDE PROJECTOR AND TAPE RECORDER, SKINNER'S "GENERAL PURPOSE" TEACHING MACHINE SYNCHRONIZED WITH 2 ENDLESS LOOP TAPE UNITS, AND A MODIFIED VERSION OF THE PORTER MACHINE SYNCHRONIZED WITH 2 ENDLESS LOOP TAPE UNITS. (LH)

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A REPORT ON INSTRUCTIONAL DEVICES IN FOREIGN LANGUAGE TEACHING

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I. Introduction

It is the intention of this report to make very specific recommendations concerning the use of devices in language instruction. However, usefulness of the recommendations rests to some extent upon contingencies not yet established, such as,the time schedule to be followed, amount of money to be put into development of devices, availability of personnel to program teaching materials for the devices, and exact use of the devices. Because of this, an attempt is made to present several alternative courses of action to fit the eventual decisions that are made. At the same time, since it is felt that one of the functions of this report is to influence the decisions which are made in developing a language instruction package, no attempt is made to hide the author's opinions.

II. The Role of Teaching Devices

There are two major functions of teaching devices in language learning: instruction and research. The two functions are closely related and feed upon one another, but the type of device chosen and the way it is used may differ considerably depending upon whether research or instruction is the major interest. In addition, there are several different roles which devices could play in the instructional process. This also has bearing upon the type of device chosen. These matters will be discussed before approaching the more technical part of the report.

The first issue is how much of the instructional process should be undertaken by devices of one sort or another, and how much should be left to the usual student-teacher interchange. There are at least two facets to this question, one involving the technical feasibility of using devices, the other being a matter of strategy and hoped-for pay-off. Concerning strategy, there is currently a poor supply of teachers of Russian, and there will continue to be a poor supply, both because of the difficulties in training good people and because of the small number of prospective teachers available for training. If it is desired to have as great an impact as possible upon the schools as quickly as possible, the larger the proportion of the teaching process undertaken by devices, the sooner the impact will be felt. In addition, it is felt that unless teaching devices take an important position in the program the result will be much like past attempts to influence the course of education -- which have depended upon recruitment appeals and conventional training techniques, and have resulted in no great impact. Put in a different way, the element of risk in concentrating a large amount of effort upon the use of devices is greater than if a conventional program is followed, but the potential pay-off is also greater. Although actual, tangible evidence for the effectiveness of teaching devices is meagre at this point, available evidence shows that "teaching machines" as used by Skinner seem to make a valuable contribution to college learning in a psychology course (1). Similar machines used by Porter show a consistent advantage over usual techniques of teaching spelling, both in terms of the quality of learning and in terms of efficiency (amount of learning per hour of machine study) (2). To this evidence may be added the generally favorable reports of the users of language laboratories (3).

Against the positive arguments above must be balanced several factors. The matter of risk has already been mentioned. The second problem is whether it is possible to produce or purchase teaching devices which will meet the specifications necessary for undertaking the entire process of language instruction. With possible exception of training in the more sophisticated aspects of pronunciation, provision of suitable teaching devices is not a problem, and the choice of one type of device over another rests primarily upon training as opposed to research interests of the project. (A more detailed discussion of the problem of training in the spoken language will appear later in this report.) The final problem is that of providing an adequate staff of competent persons to program and prepare the special types of materials needed for device mediated instruction. There are three types of personnel required for this work: a) content specialists; b) psychologists with a knowledge of instructional materials; and c) technical personnel and native language speakers to actually prepare the materials. Content specialists and technical personnel should be readily available, and the list of psychologists who have experience in the programming of teaching materials continues to grow from year to year. This latter personnel category would be most difficult to fill, however. (See appendix list of individuals who have had experience in programming teaching materials; page 19.) In addition, it is necessary to provide facilities of time and space which will allow more or less continuous contact between the psychological and content personnel over a long enough period to prepare a syllabus and complete set of instructional exercises.

If the requirements of suitable teaching devices and staff to prepare teaching materials can be met, as they undoubtedly can, then the greatest pay-off should come through as complete utilization of the devices as possible. However, if the teaching devices are looked upon as an ancillary part of the language package they are in danger of falling into the psychologically unsound pattern of use which characterizes much "language laboratory" teaching (4) and which probably has been responsible for the haphazard and generally unproductive use of "Stimulus Type" of teaching devices in the public schools (5). The recommendation of this report, then, is for as complete a utilization of teaching devices as possible; a) because of the potential contribution to a more efficient learning process; b) in order to crack the manpower bottleneck which is currently being attacked in what may be termed a "bootstraps" manner, success of which requires several generations of teachers and students; and c) because of the possibilities of transferring any findings and methodologies to other training areas.

III. Types of Teaching Devices

Since inception of the United States Patent Office hundreds of patents have been issued for teaching devices of one sort or another. Some have been marketed, but a great majority have never been produced. Of the devices which have been marketed few have had any significant influence upon instructional procedures. This is for many reasons, but one of the most important is that the devices have been poorly equipped to fully undertake the instructional process. Elsewhere it has been pointed out

that teaching devices may be classified into three major categories: "Stimulus Devices," "Response Devices," and "Stimulus-Response Devices" (6). Stimulus Devices are capable of presenting material to students, Response Devices may allow students to practice certain responses, but Stimulus-Response Devices are the only type which permit continual interaction between a student and the lesson he is studying. This interaction, in the form of questions and answers or dialogue, an essential part of the teaching process, is missing from most of the teaching devices currently used in education. Motion pictures, slides, records, and tape recorders, when used in such a way that students are not required to make explicit responses, are representative Stimulus Devices which do not arrange for this interaction. A partial explanation for the unessential part played in education by audio-visual aids can probably be attributed to their wide use as Stimulus Devices.

In foreign language teaching use has been made of auditory Stimulus Devices, for the most part. Typically, students are required to listen to records or tapes until they think they understand them. Sometimes, but seldom, are students required to respond actively to the material presented. Although relatively inexpensive and reliable equipment is available which will allow a student to listen and respond, then check up on his responses, it is not in very wide use and is used in a haphazard manner.

The most recent interest in "Teaching Machines" stirred up by B. F. Skinner has led to the design of numerous devices of the Stimulus-Response type which are capable of being adapted to a wide variety of instructional tasks, including language teaching. All of these machines possess three essential characteristics: 1) they present a sequence of problem materials one item at a time; 2) they provide some means by which a student can indicate or record his response to each item; and 3) they immediately confirm the correctness of the student's response. It is believed that some adaptation of these recent devices would be the most useful in a language package, and the descriptive material to follow will show the variety of devices possible and available.

Response

Stimulus Devices are of two major types: recognition and composition. In recognition devices a student attempts to choose the correct response from a number of alternative responses, much as in multiple choice testing, but the question and the response alternatives are <u>not</u> designed to test but to lead the student to the correct response. As soon as the student has made his choice, operation of the machine allows him to learn whether the choice was correct or not. In composition devices a student attempts to <u>compose</u>, not recognize, the required response. In the simpler type of composition device a student writes his response, operates the device in order to expose the correct response, and compares his response with the correct response. He scores himself "right" or "wrong" and moves on to the next item. In the more complex but theoretically superior composition devices a student types his answer on a keyboard, sets knobs, or in some mechanical way inserts his response. The device, which has the correct responses pre-coded, matches the student's response with the correct response and informs the student "right" or "wrong." Many variations on the basic design of recognition and composition devices have been constructed, and the reader interested in more descriptive material should refer to the bibliography at the close of this paper.

It is interesting to speculate about the design of "ideal" teaching devices capable of automatically adjusting themselves to a wide variety of students much as would a good teacher. Such devices are not technically infeasible and some have been constructed for teaching relatively well defined bodies of knowledge and performance such as International Morse Code. However, the cost, size, and complication of such devices takes them beyond any but research use at the present time. (Speculative articles on such devices may be found in Proceedings of The I. R. E. for 1957-58.) In addition it seems probable that lesson material can be prepared which is suitable for students within a wide range of individual differences in skill and background. This obviates, to some degree, the necessity for complex, self-adapting machines.

From the large number of commercially available audio-visual devices and the increasing number of new Stimulus-Response devices we are left with the problem of selecting, assembling, or designing a device suitable for foreign language instruction. The practical selection of such a device is a complex matter into which many variables enter, but at this point it will be profitable to specify what seem to be ideal characteristics. Certain of these ideal characteristics will have to be sacrificed to expediency, but it is a good idea to realize what, exactly, is being sacrificed.

First of all, an ideal language teaching device should be capable of dealing with two major aspects of language performance, the productive and the receptive. By productive language performance is meant the speaking or writing of a language; by receptive is meant the understanding or translating of a language both in its spoken and written forms. This is an important distinction to make in terms of a teaching device. If a device is to be effective in teaching the writing and speaking of a foreign language it must be able to evaluate the student's responses in that language, written or spoken, as well as being able to present stimuli which are appropriate to the responses required. This means that the device must receive or record both the spoken and written output of the student, evaluate it, and feed this evaluation back to the student so that he can alter the form or precision of the new responses he is learning, if necessary. As in the learning of any new skill, it will generally be necessary for certain of the new responses to be repeated several times in attempting to reach perfection. An ideal device would allow this repetition. On the other hand, learning the receptive aspects of a foreign language does not involve the learning of new responses, but the attaching of old responses (native language responses) to new stimuli; for instance, responding "dog" to the new stimulus "chien." Again, the teaching device must be able to evaluate the student's responses, but these responses all can be made in a written form which is much easier to handle than spoken responses. Secondly, an ideal teaching device should be capable of presenting a predetermined sequence of stimuli to the student, with the option of breaking the sequence at certain points for repetition of particular presentations.

To describe all of this in other terms, an ideal language teaching device should be capable of presenting stimuli and evaluating responses in both visual and auditory form. It should be capable of presenting a particular sequence of stimuli, with the option to repeat certain items in the sequence at discretion of the student. (Of course, such a device should

be trouble free, inexpensive, small, have high fidelity, be easy to prepare materials for, be readily available, etc.) The closest approach to these specifications is currently available through the combination of certain available magnetic recording playback equipment with the newer Skinner type of Stimulus-Response teaching device which is designed to handle graphical (printed and written) presentations and responses. In the section to follow, the many factors, practical and theoretical, which go into the recommendation of particular devices will be delineated.

IV. The Selection of a Teaching Device

A number of factors which influence the selection of a teaching device will be considered, and a specific recommendation made concerning each. In some cases there will be an obvious interaction between different factors, leading to conflicting recommendations. For instance, how expensive is it to obtain a certain degree of audio fidelity and how important is this degree of fidelity in teaching accurate pronunciation? Insofar as possible, recommendations will be made concerning which aspect of conflict seems most crucial, but final decisions will have to be determined by contingencies unknown at the writing of this report. The various factors will be considered in an order which approximates their importance in obtaining the best possible devices.

A. Machine Functions

If teaching devices are to take over a large portion of the language teaching process then it is crucial that they be capable of presenting both auditory and written stimuli, as described above. Equally crucial is the requirement that the devices give a student immediate confirmation of the correctness of his responses. This immediate "knowledge of results" has proven, repeatedly, to be of prime importance in many different types of training programs. It is of essential importance when training people to make new and different types of responses, which is the case in the productive aspects of language learning. In being able to provide immediate knowledge of results to individual students, a teaching device has an advantage over the teacher who must split her time among many. This is one reason for expecting that teaching devices, properly designed and used, can be more successful in language instruction than any teacher in a typical classroom. (For further discussion of the problem of providing adequate response confirmation see references (7) and (8).)

1. Audio Functions

Many different media are available for presenting the audio portion of a teaching device program to the student. Foremost among these are magnetic recordings and the phonograph. Each has certain advantages and disadvantages which will be weighed.

Fidelity.--Magnetic recordings are generally of a higher fidelity than phonograph recordings, primarily because the preparation and reproduction of magnetic recordings does not involve problems of transducer mass, tracking, and impedance mis-match present in acoustical recordings. In addition, unless exposed to stray magnetic fields, a magnetic recording

can be expected to have a longer life at original fidelity than a phonograph record subject to stylus wear. However, phonograph records are capable of more than adequate frequency response and fidelity to meet any language teaching requirements.

No general statement which will be agreed with by language teachers, psychologists, and engineers can be made about the minimum fidelity requirements for language recordings. Language teachers demand very high fidelity recording reproduction in order to expose subtleties of pronunciation. Aside from the problem of whether these subtleties can or should be taught in a one or two year course, it is quite obvious from a number of studies that a frequency response range of 200 to 4000 cps is sufficient for high intelligibility. From data reported in the Handbook of Experimental Psychology, p. 1056, it is apparent that an articulation score of 95% is obtainable using a frequency range of 400 to 4000 cps. The spoken material in this case was nonsense syllables, quite analogous to a foreign language. If a narrower range frequency response is necessary, loss at the bottom end of the audio spectrum is preferable to loss at the top end because 90% of the intelligibility is carried by consonants, which lie primarily in the frequency range above 1000 cps. In an informal study (carried on in The Laboratory for Research in Instruction at Harvard) it has been found that the DeJur Grundig Stenorette, with a frequency range from about 300 to 3500 cps, will give articulation scores of about 90% when the stimulus materials are difficult to discriminate syllables such as spud, stud, jud, slud, shud, thud, and fud. This should be entirely adequate for language teaching.

Ease of operation.--It is generally simpler to play a phonograph record than to thread a tape recorder, and there is no trouble with tapes breaking or snarling. A record does not have to be rewound after having been played as does a tape. In mass production it is cheaper to put out long playing records than tapes, and the cost will go down even further when presently developed long-long-play records go on the market. Despite these apparent advantages of records over tape there are two major reasons for recommending tape (or some other magnetic recording medium). First of all, tapes are technically a much simpler matter to prepare than phonograph records. Mistakes can be erased and re-recorded on the spot. Sections of a tape can be cut and spliced at will, and the end product will be durable. The preparation of phonograph records, on the other hand, involves an irreversible cutting process which produces a disk that has to go through further expensive processing if durable copies are to be made. A person of considerable technical skill must attend the recording equipment if a good product is to be obtained. The advantages of tape to a project which will be preparing trial teaching materials is obvious. A second advantage of tape lies in the high degree of control modern tape equipment has over the medium. Tapes can be stopped, started, reversed, and rewound with great ease. Equipment to do these tasks is inexpensively available. This is not so with phonograph records. In addition, the disadvantages of having to rewind tape and worry about incorrectly threaded machines can be overcome by using commerically available cartridge loops. These loops are self rewinding and as simple to load into a machine as a phonograph record. Alternatively, magnetic disks or belts could be adapted to a language teaching machine, but with considerable modification of currently available office dictation equipment.

Handling vocal responses.--For recording a student's vocal responses magnetic equipment is the obvious choice, both technically and economically. However, there is some question concerning whether an entirely separate recording-playback channel is necessary for the student's responses or whether they can be placed on a parallel channel of the audio presentation equipment. The latter alternative is more economical but will not allow flexible juxtaposition of the student's vocalization with the model vocalization, an operation necessary if immediate confirmation of responses is to be provided. We currently know so little about effective means of teaching adequate pronunciation that the most flexible possible means of presentation should be adopted, and an entirely separate recording-playback channel used.

The other alternatives to having a student record and compare his vocalizations with the pre-recorded model are only two: having a native language teacher available, or having a device capable of recognizing correct speech through mechanical means. The native language informants are not available, and neither are automatic speech recognition devices. It is difficult to say which will be sooner available, but automatic speech recognition, contrary to news publicity, faces many difficult technical problems. AUDREY, a device developed at Bell Laboratories, which automatically recognizes spoken digits is representative of the state of technical development of such devices (9). She has a vocabulary of ten or so words which are recognized with about 90% accuracy when "tuned" to certain individuals. When "listening" to other individuals accuracy drops considerably. Obviously, such devices would be of little use in teaching. The other drawbacks to automatic speech recognition, assuming it were technically feasible in the near future, are bulk and expense of the equipment.

Summary.--Assuming that the device should be capable of giving spoken language instruction without assistance from a native language speaker and without automatic speech recognition apparatus the following components are required: 1) A pre-recorded audio channel to present a question, incomplete statement, speech model, etc. in the foreign language. This function can be served by commercially available magnetic tape-loop equipment provided with appropriate controls. 2) Either a parallel recording-playback channel on the same tape or (preferably) a separate, instantaneously resetting, recording-playback device. The preferred device can be adapted from either commercially available equipment or from special telephone equipment. 3) Devices will need to be equipped with simplified controls for volume and for tape movement.

2. Visual Functions

The presentation of visual language learning materials and recording responses to these materials presents, in some ways, a more complex problem than the handling of audio materials. Mainly, the problem is simply that commercially available equipment does not possess the necessary degree of flexibility. However, there is commercial apparatus adaptable at minimum effort, and specially designed teaching machines which can be used with certain compromizes may be available soon.

Visual presentation.--Three methods of presentation will be considered, each of which has advantages and disadvantages. Moving pictures, according to extensive research (10), may have dramatic, highly motivating

characteristics and are capable of close realism. However, a great deal of the dramatic effect is a result of what is done with the medium, rather than the medium itself, and unless dramatic and dynamic motion effects are needed in language teaching, the technical difficulties of film production should be avoided. Even with the technical simplifications brought about by video tape, producing moving pictures would be a complex business, expensive and time-consuming. If one of the aims of language instruction is to enable students to interact spontaneously in the new language this can probably be effectively accomplished by structuring real, social situations (as at Middlebury and other colleges).

The two remaining media for controlled presentation of textual and pictorial materials are by projection of still films (slides or strip) and direct viewing of matter printed on an opaque medium. Here, a choice depends upon convenience of preparing the materials and availability of devices for presentation. If it is anticipated that a relatively small number of copies of the teaching materials will be produced, at least in early stages of the program, then printing is needlessly expensive, and photographic or other "small run" reproduction techniques should be used. If many copies of materials are required it is suggested that conventional spirit or mimeograph duplication procedures be used. Available teaching machines and currently planned devices, however, all require the use of special and expensive reproduction techniques in preparing materials which are printed on paper disks, tapes, or drums. A suitable device for presentation of easily prepared materials would therefore have to be developed. (See reference 8 for a simplified version of what could be developed.)

Considering the current unavailability of teaching machines which can use easily prepared materials, and assuming that it would not be desirable to develop a new device, it is suggested that a modified slide projector could be used for presentation. There are several advantages to this solution. The projector can be equipped with a small opal glass screen for individual use or the screen could be removed for teaching groups by projection. Several currently available slide projectors are equipped with solenoid actuated slide-shifting mechnaisms which allow synchronization with a spoken presentation. Slides are easily prepared by typing or drawing on cellophane which is then ready for immediate use or immediate reproduction by the simple and rapid Polaroid slide maker set-up. Slides are stored in magazines which are easy for a student to load into the machine, and the order of presentation can be changed readily -- an operation impossible with strip film or continuous printed matter. It is relatively simple to synchronize a slide projector with taped presentation by means of one of the commercially available low frequency synchronizer units which operates on an impulse from the recorded material. The disadvantages of using a slide projector are that it would have to be modified and a separate unit added upon which students could write their responses. It is not known whether this would be as expensive and time consuming as developing a new teaching machine for the visual instruction or not, but past experience in developing the simplest sorts of teaching devices indicates that a year is needed (under university conditions) for design, experimental models, and ironing the faults out of final models.

Handling written responses.--As was the case with a student's spoken responses, it is necessary to provide some means by which written responses may be put down for comparison with the correct response. This step, which

provides immediate confirmation of the correctness of responses, is crucial. Current teaching machines are set up so that a student writes his response either on the teaching material or on a parallel paper tape. Movement of a lever exposes the correct answer and moves the student's answer under glass so that it cannot be changed. The student then makes his comparison, scores himself, and brings up the next question. Such an arrangement is more economical if responses are written on the parallel tape and do not use up the teaching materials, but such an arrangement requires more complex mechanisms. For research purposes it is easier to analyze the student responses if they are directly on the teaching materials, but relatively simple techniques can be devised to obtain the same data from parallel tapes. If the language programs developed are to be tried out in any extensive manner it would be preferable to use parallel response tapes and provide special instrumentation for gathering and analyzing the student responses.

If one of the current teaching machines is used in the project, a most likely prospect would be the "general purpose" disk machine used by Skinner. This device has the parallel tape response system. Another alternative would be to make a modified version of the Porter device (11) which would have the advantage of easily prepared materials. A final solution lies in the providing of a written response tape which could be synchronized with the slide projector presentation, using the same means of synchronization as between slide and tape. This solution, however, would require the design and construction or purchase of the response unit.

Summary.--Assuming that the device should be capable of giving visual presentations in sequence, providing means by which a student can record his written responses and obtain immediate response confirmation, the following alternatives are available. 1) Visual presentation by slide projector or opaque presentation device. This function could be served by a modification of commercially available slide projectors, by one of the current teaching machines or a modification of one, or by an extensive modification of the Porter teaching machine. 2) Recording of student written responses could be handled by current teaching machines or a specially devised paper tape mechanism to operate in parallel with a slide projector. 3) If a parallel tape system is used some means should be provided to enable convenient analysis of student responses to the teaching materials.

3. Combined Functions

Although the above visual and auditory functions have been discussed separately, they should be combined into a suitable teaching device. It would be feasible, and perhaps more economical, to provide separate devices for the visual auditory modes of teaching but only with the loss of effectively combining instructional methods. Very little is known about such matters, psychologically or pedagogically, but it is possible that effective use of combined visual and auditory stimuli would result in more than commonly expected learning. Separate devices would also require that students synchronize them when necessary, a procedure which could easily lead to errors and possible cheating. Therefore, it is strongly recommended that any teaching devices provided be equipped, in one unit, for the entire instructional process.

In the following "block diagram" the essential units of such a teaching device are represented along with their interconnections and relationships to the student. The physical layout is roughly that which would be suitable, but the diagram is meant to be entirely schematic, not pictorial. Lines drawn between the various components represent electrical and/or mechanical connections necessary for synchronization and student control of the device functions. Depending upon what components are finally chosen, the units represented below are the following:

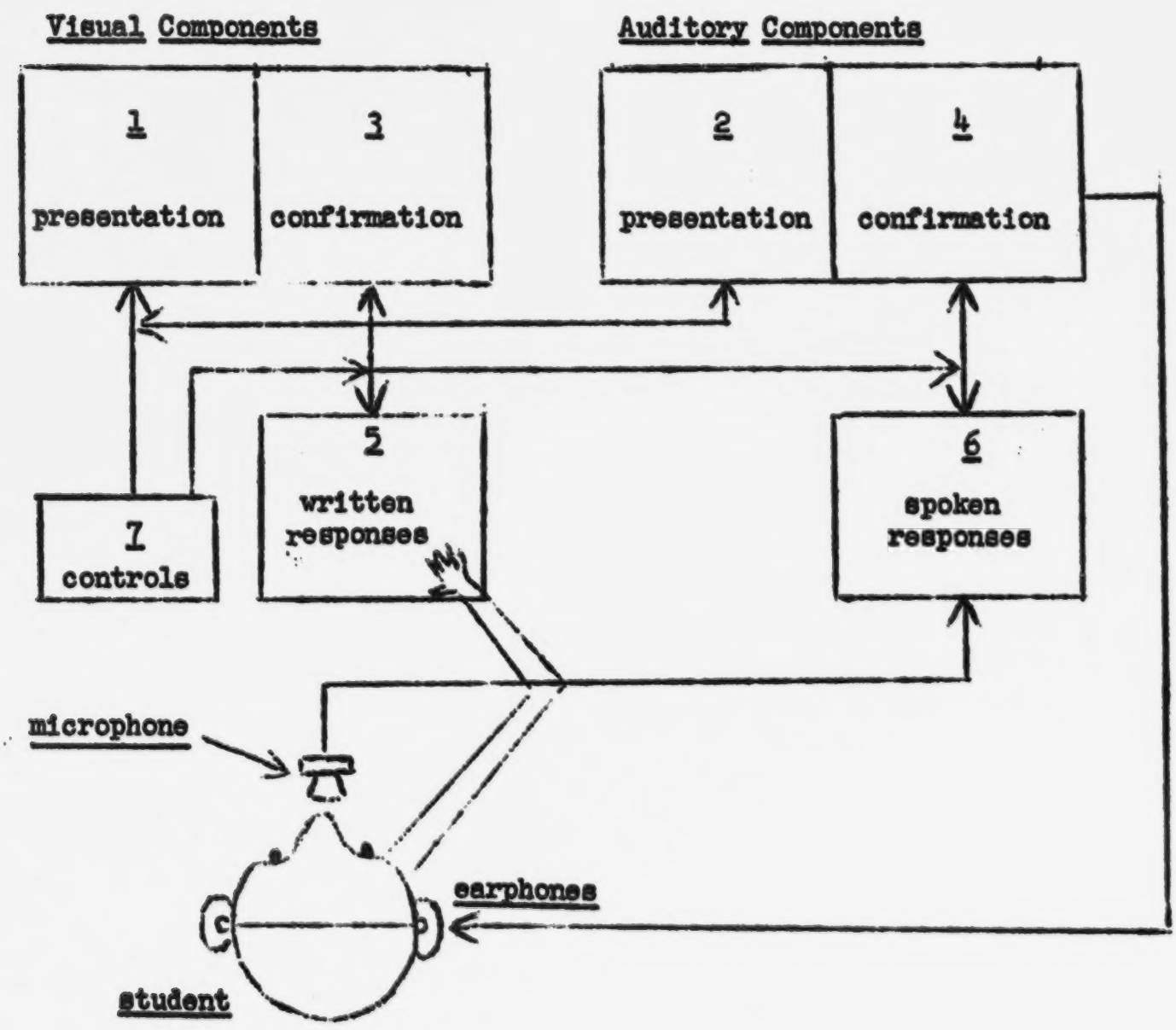
a) units 1, 3, and 5 -- Skinner's "general purpose machine or modified version of Porter device; or

b) units 1 and 3 -- modified automatic slide projector in conjunction with unit 5 -- specially designed written response unit and unit 7 -- specially designed controls.

c) units 2, 4, and 6 -- dual channel cartridge-loading endless loop-tape recorder playback unit; or

d) units 2 and 4 -- dual channel cartridge-loading endless loop-tape playback unit in conjunction with unit 6 -- special recording-playback unit with rapid reset feature.

Final selection of component units depends upon further considerations to be presented below.



B. The Concepts of Programming and Editing

Programming.--The term programming in the sense it will be used here refers to the process of constructing sequences of instructional material, most usually conventional textual material. Instructional materials, of course, are a crucial aspect of any teaching, whether the material is presented by a teacher or a teaching device, so that the ultimate success of any venture such as a self-contained language instruction unit depends upon the adequacy of these materials. Currently, very little is known about techniques of programming. The usual methods involve artful manipulations by good teacher-writers who are dissatisfied with available texts, but very little can be said about their methods, in general; the manipulations they perform are of a subtle, subjective, and non-verbalized nature.

On the other hand, there are a number of more or less generalizable principles of programming which are derived from reinforcement theory along with others developed in attempts to write successful teaching programs for teaching machines. The reader should refer to articles by Skinner (1) and Gilbert (11) for extended descriptions of specific programming techniques and examples of sequences of teaching items. However, an outline of these principles will be presented below.

There are two basic principles which have served to guide all other operations in preparing teaching materials: 1) Immediate knowledge of results (confirmation or reinforcement) is highly motivating and essential for efficient learning; 2) In the teaching of any complex behavior such as speaking a foreign language it is not possible to wait for the correct behavior to appear so that it can be reinforced, because the behavior will never appear. It is necessary rather to lead the student gradually to make a final, complex performance by "shaping" successive approximations to the final act. For instance, reading a page of German text involves many subtle acts which combine into a total response that it would be impossible for a beginning student to make, no matter how hard he tried or how long the teacher waited, and conversely, it would probably be psychologically impossible to teach the student to translate the page by one or two simple acts of instruction. What is required is a sequence of responses by the student involving components of the final task, each response involving a reinforcement in the form of knowledge of results about how successful the response has been. In practice this has meant the following operations have had to be carried out on the teaching materials.

1) The subject matter to be taught is broken down into a large number of steps, each requiring the student to make an explicit response and receive an explicit reinforcement in the form of knowledge of results. The large number of steps are a result of attempting to teach as many of the subtleties of the subject matter as possible, and are necessary in order to keep the possibility of making a wrong response at a minimum. There should be a concern over wrong responses for two reasons: lack of success as a student has a detrimental motivational effect, and wrong responses which are made through ignorance or by chance are difficult to get rid of. They are likely to appear again even after the correct behavior has been learned. In other words, the preparation of teaching machine material is not analogous to the preparation of testing material in which some items are deliberately chosen for their difficulty.

2) On the other hand, the object in preparing teaching machine programs is not to select items which the subject already knows, but to prepare items which give new information which when added to the student's previously acquired knowledge will enable him to produce responses he could not have given before.

3) In the earlier portions of a teaching program the student is deliberately enabled to give the correct response because of the presence in the item of a hint or prompt. The prompt may be something entirely irrelevant to the subject matter being taught, as printing all odd numbers in red, all evens in green, and writing the item in red if the correct response is an odd number. (This type of technique is used frequently by some elementary school teachers.) If this sort of "irrelevant prompt" is used to obtain a correct initial response, then the programmer has to shift control of the student's behavior to a more relevant portion of the environment once the correct response has been made available. A technique of prompting which is preferable would be to use naturally occurring, relevant prompts, such as teaching that a more technical term for the word "reward" is _____, a term which means to strengthen (correct response is reinforce).

4) Items further along in the teaching program are provided with less information and prompts so that the student is more on his own. This has been done by a number of "fading" and "vanishing" techniques in which words are partially deleted, formal syntactical cues are removed, and minimal support is provided by immediate memory of preceding related items in the teaching sequence.

5) Responses taught earlier in the teaching sequence are salted into later portions of the program, systematically, in order to augment the meaningful context of the relevant knowledge taught and in order to provide review.

It is not suggested that the above procedures are any final word in programming instructional materials or that they are even sufficient for writing a self-instruction language course, for knowledge of programming is meagre at this time. However, it is felt that some set of principles such as above, used in conjunction with the intuitions of good language teachers and the knowledge of language experts should produce superior teaching materials. It should be emphasized that the use of mechanical teaching devices will make possible the exploitation of instructional techniques seldom or never attempted before. Some of these techniques may oppose current opinions and practices of the language teaching profession. It would be disheartening to not attempt these techniques, which have sound psychological rationales, simply through failure to provide personnel with appropriate psychological training.

Editing.--Closely related to the tentative nature of our knowledge of programming teaching materials is the concept of editing as a research and experimental activity. Traditionally, editing has been a task reserved for publishers who hire individuals skilled in the intricacies of English style and grammar. The activities these individuals engage in has little to do with the content or arrangement of content in the texts being edited, this matter having been taken care of, presumably, through the hiring of an author who is an authority in his field, and who may also. sometimes, be an outstanding teacher and writer. Programming of the textual material

is left entirely up to the knowledge, skills, whims, and biases of the author, and any validity the materials have depends upon the soundness of the author's judgment about how much the textual materials contribute to his teaching, a matter usually confounded by other instruction the students receive in the form of lectures, discussions, and outside readings. The use of teaching machines in an entirely, or mostly, self-instructional set of lesson materials should allow the authors or publishers of the materials to overcome the above editing difficulties, however. Student responses to the teaching sequences can be analyzed and the materials modified and tried out again as many times as necessary to perfect the lessons. In fact, it would seem mandatory to utilize this research function made possible by teaching devices; to not do so would be to pass up one of the greatest long term advantages of such teaching techniques, the possibility of gradual cumulative revision and perfection of lessons based upon factual findings rather than educated guesses. Such research techniques have paid off handsomely in other areas of technological advance and can be expected to do the same in education.

If it is anticipated that such research-editing activities will be undertaken in the current project then it is mandatory for the teaching devices used, or at least some of them, to be equipped to facilitate the research. Such facilitation requires the following features.

1) Teaching devices which will accept easily prepared and modified sequences of visual and auditory material. Magnetic recordings are eminently suitable for the auditory presentations, and a modification of the Porter device would provide the most feasible visual materials because of the use of standard paper sizes and duplication processes.

2) Techniques for the easy analysis of student spoken and written responses. The analysis of spoken responses in the form of recordings is an arduous and time-consuming task. One feasible manner of speeding up such work is to provide some sort of recorded signal on the tape at the point where error responses lie (such signals could be automatically placed on the record every time a student indicates himself as having made an incorrect response). Then for analysis the tape could be sent through a playback device at high speed until one of the signals shifts the machine to an appropriate playback speed. This could be a modification of a normal tape machine. The analysis of written responses presents something of the same problem, but not to such a severe extent because of the speed of human visual scanning compared to listening. Basically, there are two techniques which can be followed. The first involves having the students write responses directly upon the teaching materials and scoring themselves "correct" or "incorrect" by an appropriate mark. Analysis of these responses would proceed by visual inspection, and for 100 or so students would not be too cumbersome a scheme. A more automated procedure would be for the responses to be placed upon a separate parallel paper tape. As a student scores himself a hole could be automatically punched in the tape next to each wrong response. Then the tape could be sent through a special sensing device which would stop at each punch mark to enable examination of the wrong response. This scheme would, of course, be more expensive and probably is unnecessary unless a very large number of student responses is to be analyzed (upon the order of several hundreds of students).

4) The teaching devices should be flexible enough to allow investigating all possible combinations of visual and auditory presentation, response, and confirmation within the limits of tape recordings and still pictures. To provide insufficient research flexibility would be to invite perpetuation of time-honored techniques of teaching which there is some hope of improving.

C. The Possibility of Using Complex Electronic Equipment

There are two ways in which complex electronic equipment could materially aid the language teaching process: through the provision of devices which would adjust themselves to individual differences in students; and by means of special techniques to aid in the teaching of foreign speech. Both would be expensive, cumbersome, and require long periods of development time in order to be made satisfactorily operational. A safe rule of thumb estimate to follow is that cost, operational difficulties, and development time increase geometrically with complexity of equipment. For this reason it is recommended that unless the language project is willing to devote a number of years to equipment development, teaching devices be kept as simple as consistent with obtaining adequate presentation and confirmation of the lesson materials.

If long term development of special devices is anticipated there are several techniques which should be considered. In the matter of adjusting to individual differences in students there are several procedures which can be followed. Teaching materials can be "skip programmed." If the entire lesson involves 2000 items for the student to respond to, the initial stages of the program can require the student to respond to only every fourth item. When few student errors are made an individual can proceed throughout the entire lesson in the same fashion, but whenever a significant number of errors are made the device automatically shifts to presenting every second item. In this manner, the better students could go through the material more rapidly than the students with poorer background or ability. Another self-adjusting procedure would be to have the students do all items in a lesson, but have the teaching device back-track and go over the same material again if errors become frequent. A preferable technique would be to have the machine back-track to a new and different, perhaps longer and easier, sequence of items covering the same material. All of these techniques considerably complicate a teaching device, and probably can be handled alternatively by careful programming of one set of materials or by close administrative supervision of use of the teaching devices.

Giving adequate speech instruction and practice in a foreign language is a more complicated problem, especially the training of "native" pronunciation. The student is usually encumbered by his own native language, which has sounds subtlely different from those of the new language and is entirely vacant of other sounds prominent in a new language. The problem is usually complicated further by orthographic differences and irregularities. Often it is difficult for a student to even discriminate important differences in foreign speech because such phonetic distinctions are not made in his native language. In a practical teaching situation such problems are handled by native speaking instructors who have to work almost individually with students in order to catch and remedy the speaking flaws as they occur. The use of teaching devices may make it economically possible for each student to have an individual "tutor" to handle this aspect of language

learning. However, since such devices will depend upon a student's recognizing how good his own pronunciation is when compared with a standard, the procedure is open to errors caused by student misperception of the foreign speech. One obvious solution to this problem is to provide devices capable of recognizing correct speech and informing the student whether his pronunciation is up to par. As was pointed out earlier in this paper, such speech recognition devices are not available at this time, and although they may become available within the next ten years, cost, complication, and inconvenience would preclude all but fixed and central location use in teaching.

Other possible instrumentation in spoken language instruction involves special forms of visual and auditory display of the details of pronunciation. For instance, it is conceivable that a cathode ray tube display of the time, frequency, and intensity characteristics of a student's speech could be compared by the student with a simultaneously available visual model of correct pronunciation. Again, such instrumentation would be complex, especially if the device is to make possible an almost instantaneous comparison of the dynamic features of speech, as it must in order to be of much use in reinforcing correct vocalizations. It is also questionable whether students would be capable of reading the complex visual display -- language experts have difficulty in reading the static displays provided by a "sound spectrograph" in an already known language. Perhaps a more fruitful type of instrumentation could be provided by presenting and having students attempt to copy speech models modified in temporal and frequency characteristics. For instance, the correct pronunciation of certain sounds or words might be simplified by having the auditory model presented at a slower pace, allowing more time to listen to inner structure of the vocalization. Or filters could be inserted into the speech circuits in order to remove certain components of the total vocalization which tend to mask smaller but important details of pronunciation. Little is known about the effect of these auditory manipulations of language learning materials so that a good deal of experimentation using relatively complex equipment would be necessary in order to obtain workable teaching procedures. This type of manipulation of learning materials, however, lies close to the concept of "shaping" behavior mentioned earlier. One flaw of much spoken language instruction has been that the teacher expects his students to attempt the final, complete and correct pronunciation at the start, despite interference from former language habits and the complexity of the muscular movements involved in pronouncing new sound combinations. This procedure is almost as psychologically unsound as requiring a student to translate a page of foreign text de novo. What should be attempted instead, is to lead the student through a series of different pronunciations which approximate the final objective. This process should take into account the particular ways in which the student's native language interferes with the new language and the sequence of steps should attempt to forestall the usual mispronunciations which students make. The above mentioned techniques for manipulating auditory materials could form an integral part of this type of teaching process, and it is felt that this approach, rather than attempts to use automatic speech recognition will produce greater pay-off.

V. Summary and Recommendations

The recommendations to be made fall into three major categories: the role of teaching devices in the development and use of a self-instructional language package; the problem of programming lesson materials; and the selection of appropriate devices.

The role of teaching devices.--It has been suggested that the role of teaching devices be major because of the potential pay-off through application of technology to the educational process. A successful technology of teaching devices could result in economic and manpower advantages which usually have to await the rise of a new generation of teachers trained in the desired discipline, in this case, the Russian Language. It is also felt that less than full utilization of devices could lead to dependence upon traditional instructional techniques often based more upon personal whim and prejudice than psychological knowledge. Despite the great potential contribution of teaching devices to language instruction, it should be warned that they are no "pie-in-the-sky" to cure the ills of traditional education. We are only in the initial stages of developing a technology of instruction, and much experimentation remains to be done.

Programming lesson materials.--With teaching devices as in any type of teaching, the selection, organization, and presentation of educational content is a major problem. This is an area in which little systematic research has been done, primarily because teachers responsible for academic content have had neither the motivation nor the skills necessary for the task and psychologists have been more interested in exploring basic behavioral processes than in applying their knowledge to practical problems of teaching. The teaching device provides a research instrument par excellence which makes feasible the exploration of innovations in teaching and provides a focal point for collaborative work between academic content specialists, teachers, and psychologists. This collaboration is long overdue, and the fruits of such an interdisciplinary endeavor could be useful to education as a whole.

The selection of appropriate devices.--The selection of teaching devices for the language project rests upon a complex of interacting factors, and the importance of particular factors depends upon exactly what purposes the project turns out to involve. Most important is the provision of appropriate psychological functions: ability to present auditory and visual materials to the student; providing the student a means of responding; and confirming the student's responses. Next in importance is sufficient flexibility to allow all possible combinations of presentation and confirmation of lesson materials. Directly related, insofar as editing as a research function is important, is the necessity of providing for easily and inexpensively prepared materials to be used in the teaching devices. Finally, there are considerations of simplicity, reliability, economy, and time. The following specific devices each have certain advantages and disadvantages which will be mentioned along with the specifications listed.

1. Special combination slide projector and tape recorder produced by the Amplifier Corporation of America for the Navy Special Devices Center. Slides and sound are synchronized. Visual confirmation would have to be placed upon next slide in the projection sequence. Student's written

responses would have to be placed upon a separate sheet of paper (could be unsatisfactory depending upon the nature of the teaching material) or upon a specially constructed written response unit. The best choice for relatively inexpensive and readily available equipment. Materials relatively easy to prepare.

2. Skinner's "general purpose" teaching machine synchronized with two "Mohawk Message Repeater" endless loop tape units. Cost and delivery uncertain on the Skinner machine. Visual materials relatively difficult to prepare and edit. Good means of providing for student response confirmation. Most fool-proof and cheat-proof visual presentation mechanism. If provided with a modified version of Western Electric "Answer Only Set (12)," would give the most flexibility in presentation and confirmation of all devices. This would be excellent for research if it were not for difficulties in preparing visual materials.

3. Modified version of Porter machine synchronized with two "Mohawk Message Repeater" units. Student's written responses taken care of by device either on tape or original teaching materials. Modified Porter machine relatively inexpensive (the simplest of all the devices) but would require the engineering necessary for modification. Teaching materials very easy to prepare by standard duplication processes. Excellent for research except that "repeat" feature of Skinner machine is not available.

For research purposes, the auditory sections of any of the above devices could be equipped with various instruments designed to manipulate the time and frequency variables of the presentation for research or teaching purposes.

In the final analysis, if the project is to undertake a many-pronged and long term attack upon language learning it would be appropriate to consider designing an original device or perhaps acquiring several different devices for different aspects of the project.

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APPENDIX

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